

# PROFESSIONAL INTERVIEW ESSAY

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During your tenure as Project Manager at Technisystems (M) Sdn. Bhd., Kuching, Sarawak, you were involved in the limestone quarry operation. What were the technical data required in the design of the quarry, drilling and blasting and transporting of blasted blocks of limestone to the crushing plant? What were the problems encountered during the quarry operation? How were these problems addressed?

## INTRODUCTION

Prior to designing a quarry and the related design works such as the haulage road (for the transportation of blasted material from the quarry face to the crushing plant), and drilling and blasting, relevant preliminary data is required to be collected and made available. This data includes geology of the deposit, drill core logs, laboratory test results on the rock sample of the deposit, topographical maps of the deposit and its surrounding area, and also the environmental impact assessment of the surrounding area. Sometimes, this data may be available but need to be verified and confirmed. After the availability of this preliminary data, the setting of the technical data that is required in the design of a quarry and the related design works can then commence.

There are no two quarries with similar designs, mainly due to the difference in rock type, geological setting and structure, and the topography of the deposit. Nevertheless, there are common quarry design parameters or technical data which have to be taken into consideration when designing a quarry. These technical data includes quarry pit limit, quarry pit design parameters, waste disposal, drainage system, and haulage road.

The problems encountered in the limestone quarry operation are mostly related to the drilling and blasting activities such as fragmentation, toe, and penetration problems.

## QUARRY DESIGN PARAMETERS

### Quarry Pit Limit

Quarry pit limit is the first design consideration for a quarry project, and it does not necessarily fall within the boundary of the approved quarry license area. The delineation of the quarry pit limit usually has to consider other factors such as the geological setting and topography of the deposit, the overall layout of the quarry, the specific mining reserve, and the surrounding environment.

### Quarry Pit Design Parameters

A quarry is to be designed in such a manner that will ensure safety and allow easy flow of all activities on site. The quarry pit design parameters that are taken into consideration include:

- first bench (highest) and last bench (lowest);
- bench height;
- width of working platform;
- safety berm width;

- final pit slope;
- final bench slope; and
- total number of benches required.

Again, the decisions on the quarry pit design parameters have to be considered and be carefully analysed based on the relevant data such as the type and nature of the rock, geological structure, and topography of the deposit.

## Quarry Waste Disposal

The overlying waste material of the deposit is referred to as overburden, and it will be stripped to expose the good rock material for quarrying. The excavated quarry waste material is dumped at designated area referred to as the waste dumpsite. A benching system of dumping is usually adopting for the waste dumpsite. The maximum waste dumpsite bench height does not exceed 10 metres depending on the nature of the waste material, and usually 5 metres of berm is maintained. The overall slope of the waste dumpsite is usually between 30 to 45 degrees.

Bulldozers are used to push and compact the waste dump material to avoid any landslide or dump collapse that may cause hindrances to the other operation. The final waste dump surface will be trimmed, compacted and grassed to avoid soil erosion. Drainage ditches will be constructed around the waste dumpsites to collect surface runoff, seepage or effluent water, to be directed to a sedimentation pond or a retention pond before discharging into the nearby natural water courses.

## Drainage System

The surface runoff as a result of rain demands much attention when designing a quarry. Therefore, quarry site drainage system design is an essential step that should focus on restricting the extraneous water entering the site and managing surface runoff leaving the site.

The surface runoff is directed around the quarry site using drains, and collection and diversion ditches. The quarrying areas, the main haul road, and the internal access roads will also need to be adequately drained. This collected runoff together with any excess water from the disturbed areas of the quarry sites will be directed into a sediment trap or a retention pond strategically located prior to discharging from site.

## Haulage Road

The main technical data involved in the design of the quarry haul road includes width, length, turning radius, and grade. The final designed haul road should be safe for traffic to use, which means the haul road should have ample space for traffic to travel. The width of the haul road is determined based on the size and numbers of trucks using the road. The length of the road is based on the location of the quarry face and the crushing plant and the topography. The turning radius of the haul road is determined based on the type and size of trucks, which is usually around 30 meters. For safety reasons, the grade of the haul road is usually designed between 8 to 10 percents depending on the topography of the quarry.

## DRILLING AND BLASTING DESIGN PARAMETERS

Blast design is not a precise science. Because of the wide different types and nature of rocks, geological setting and structure, and types of explosives, it is impossible to set down a series of equations to enable the blaster to design the ideal blast without some

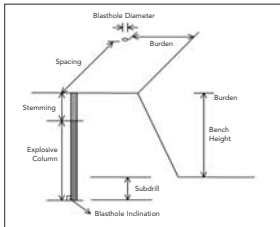


Figure 1. Blast Design Parameters

field testing. Therefore, field testing is required to refine the initial proposed blast design to suit individual quarry situations. The essential blast design parameters that are taken into consideration include blasthole diameter, blasthole inclination, burden, spacing, subdrill, stemming, bench height, blast pattern, and initiation system. The essential blast design parameters are shown in Figure 1.

### Blasthole Diameter

The size of blasthole is the first consideration for any blast design. In Malaysia, the diameter of blastholes for quarry operation normally ranges from 70mm to 127mm. For quarry operation, smaller diameter blastholes are preferred mainly because it will improve rock fragmentation and cause less ground vibrations.

### Blasthole Inclination

Inclined drillholes provide better charge distribution and are very effective in overcoming toe problems and reducing overbreak. However, it

is difficult to drill inclined holes to the required azimuth and inclination. It is more prone to deviation as the inclination of the drillhole increases.

### Burden

The burden is the distance from a blasthole to the nearest free face at the instance of detonation. Due to the complex mechanical breakage of the rock, field testing must be carried out to determine the right burden for the individual quarry. As a starting point the following formula may be used to determine the initial burden:

$$\text{Burden (m)} = (30 \text{ to } 45) \times \frac{\text{Blasthole Diameter (mm)}}{1000}$$

(Use a figure of 30 for very hard massive rock and 45 for soft rock)

### Spacing

Spacing is the distance between adjacent blastholes, measured perpendicular to the burden. The spacing is usually between 1 to 1.5 times the burden. ■

### Subdrill

Subdrill is the distance drilled below the floor level to assure the full face of rock is removed. A good first approximation for subdrill under average conditions is about one third of the burden.

### Stemming

Stemming is the distance from the top of the explosive charge to the collar of the blasthole. This zone is filled with inert material and it should be dry, angular and not easily crushed. Size of material should be approximately 1/10th to 1/12th of the blasthole diameter to give some confinement to the explosives gases, and thus reduce airblast. Under normal condition the stemming is at least equal to the burden.

### Bench Height

In any blast design it is important that the burden and the bench height be reasonably compatible. As a rule of thumb, for bench blasting, the bench height to burden ratio should be between 1.5 to 4.0. However, the determination of bench height should consider other factors such as the topography and layout of the overall quarry, the crushing and the screening plant; hardness of rock (very hard rock require at least twice the burden of explosive column); the size of the drilling machine (a large drilling rig can drill deeper and straighter holes); and also vibration and airblast limits.

### Blast Pattern

There are three commonly used blast patterns: square, rectangular, and staggered. For the square pattern, the spacing is equal to the burden, whereas the spacing is longer for the rectangular pattern. Field testing for each pattern should be carried out in order to confirm the right pattern for the individual situation.

### Blasting Initiation system

There are a few types of initiation systems, which include electric, non-electric, cap and fuse, and detonating cord. Each initiation system has its advantages and disadvantages. A nonelectric initiation system is usually preferred for a number of reasons which include: (1) it is safer and easier to use; (2) it provides greater flexibility in that delay elements can be placed on the surface and also in the down hole; (3) reliable; (4) less vibration and noise; (4) better fragmentation; (5) economical; and (6) individual hole per delay can be achieved regardless of the number of holes.

### PROBLEMS ENCOUNTERED IN LIMESTONE QUARRY OPERATION

The problems encountered during quarry operations in a limestone deposit are usually related to the drilling and blasting activities. These are:

#### Fragmentation Problem

The limestone deposit is usually fractured and highly weathered for the initial eight (8) meters from the surface of the deposit. As a result, the drilling penetration rate through this weathered zone faces many difficulties. Furthermore the explosive gas escapes in all directions in this zone resulting in a fragmentation problem at the edge or circumference of the hill. This problem can be overcome by horizontal drill holes, however this will incur a higher cost. In some cases, two or three 70-degree incline drill holes about one meter away from the highly weathered and fractured material may be required to achieve the required drill depth, and thus reduce the fragmentation problem.

#### Toe Problem

Limestone that is highly fractured is the major factor contributing to the

toe problem. Other factors which contribute to the toe problem include uneven ground surface which cause some of the drill holes to not reach the same drill level, diverged drill holes, excess burden and spacing, wet holes, unsuitable primer, or not enough subdrill.

The approaches to minimise the toe problem include: (1) accurate survey of the elevation of each drill hole to determine the actual drill depth before drilling; (2) drill straight holes (reduce the penetration rate when necessary to avoid deflection); (3) use the right burden and spacing; (4) pump the hole dry before charging; (5) use the right type and quantity of primer, and place the primer in the blasthole at the floor level; and (6) use right length of subdrill.

#### Penetration Problem

Limestone deposits can be highly weathered and fractured, with the occurrence of massive cavities. Due to this geological nature of limestone deposits, penetration problems are often encountered during drilling operations. Quite a number of drill holes in each individual blast pattern do not achieve the required drill depth. To minimise this problem, the approach is to reduce the bench height of the first two working benches from 15m to 10m, or even less.

### CONCLUSION

Every quarry is unique in its design due to the difference in rock type, geological setting and structure, and the topography of the deposit. The technical data that is required in the design of a quarry, drilling and blasting, and haulage road not only has to consider the economic factor, but also safety, as well as environmental factors. The problems encountered in the quarry operation can be solved or as least minimised with proper management and a technical approach. ■